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POSSIBILITIES OF REDUCING BLOOD LOSS DURING TANGENTIAL NECRECTOMY IN BURNED PATIENTS (LITERATURE REVIEW)

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Abstract. Early surgical treatment of burn wounds is one of the priority areas of kombustiology. Excision of devitalized tissues before the development of a purulent-inflammatory process in them has a directed pathogenetic justification for the effectiveness of the manipulation. Removal of necrosis in the affected area reduces the intensity of intoxication, as well as accelerates the transition of the wound process from inflammation to the regeneration phase (classification of M.I. Kuzin). One of such techniques is early tangential necrectomy, which is currently not widely used in clinical practice due to a number of critical shortcomings. The main ones include the lack of an objective method for controlling the selectivity of tissue excision, a high incidence of complications in the early postoperative period, as well as the instability of hemostasis. Studies on this topic have allowed us to establish that the volume of blood loss during early tangential necrectomy depends on the timing, depth and method of excision of the burn scab, the choice of tactics of intraoperative hemostasis and systemic therapy. An in-depth analysis of these areas made it possible to identify the main causes of unsatisfactory results and identify possible ways to improve them.

Key words: burns; deep skin burns; early surgical treatment; necrectomy; tangential necrectomy; hemostasis.

ВОЗМОЖНОСТИ СНИЖЕНИЯ ПОТЕРИ КРОВИ ПРИ ВЫПОЛНЕНИИ ТАНГЕНЦИАЛЬНОЙ НЕКРЭКТОМИИ У ОБОЖЖЕННЫХ (ОБЗОР ЛИТЕРАТУРЫ)

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Резюме. Раннее хирургическое лечение ожоговых ран является одним из приоритетных направлений комбустиологии. Иссечение девитализированных тканей до развития в них гнойно-воспалительного процесса имеет направленное патогенетическое обоснование эффективности проводимой манипуляции. Удаление некроза в области поражения позволяет снизить интенсивность интоксикации, а также ускорить переход раневого процесса из воспаления в фазу регенерации (классификация М.И. Кузина). Одна из таких методик — ранняя тангенциальная некрэктомия, которая в настоящее время не получила широкого распространения в клинической практике в связи с рядом критических недостатков, к основным из которых можно отнести отсутствие объективного метода контроля селективности иссечения тканей, высокую частоту осложнений в раннем послеоперационном периоде, а также неустойчивость гемостаза. Исследования по данной тематике позволили установить, что объем кровопотери при ранней тангенциальной некрэктомии зависит от сроков, глубины и метода иссечения ожогового струпа, выбора тактики интраоперационного гемостаза и системной терапии. Углубленный анализ указанных направлений позволил выявить основные причины неудовлетворительных результатов и определить возможные пути их улучшения.

Ключевые слова: ожоги; глубокие ожоги кожи; раннее хирургическое лечение; некрэктомия; тангенциальная некрэктомия; гемостаз.

Early excision of burn scab has been one of the most significant advances in modern combustiology. Historical advances in understanding the pathophysiology of burn injury and the systemic inflammatory response caused by the burn wound, as well as improvements in the technique of tangential and fascial excision of necrosis, have led to the possibility of early skin repair in the area of a deep burn wound, leading to a reduction in mortality [5].

One of the main intraoperative problems of burn wound surgery is the precision excision of the dead tissue layer while avoiding damage to the viable layer and massive bleeding. The problem is becoming more and more urgent, as the share of elderly burn patients with extensive deep burns and a large number of concomitant diseases in the structure of traumatism is growing, in whom only surgical intervention performed in early terms gives a chance for a favourable outcome. The presence of necrotised tissue may be a factor hindering the wound healing process as it may cause progressive tissue damage leading to delayed wound healing [26]. According to the observations of other authors [22], delayed necrectomy in burned patients increases the degree of neutrophilic infiltration of the tissue under the scab, and there is death and loss of skin appendages. On the contrary, after tangential necrectomy the severity of inflammatory reaction in the postoperative wound decreases, there is an early development of full-fledged granulation tissue and epithelialisation.

Tangential excision of necrosis to viable tissues in border and deep burns is necessary for optimal graft engraftment, but it is often accompanied by bleeding of the extensive postoperative surface [11]. Often, the planned operative blood loss is a major factor that determines the amount of excision in a single surgical procedure.

There are a number of common methods to determine the amount of intraoperative blood loss. The visual method is based on the subjective opinion of operating team (surgeons and anaesthetists), based on their perception of the volume and features of the operation performed, as well as professional experience. Empirical method is based on the fact that there is a stable relationship between the area of scab excision and the volume of blood lost — from 0.5 to 3 ml per 1 cm^2 of excised scab, taking into account losses from donor wounds [1, 18, 30]. Its accuracy is rather doubtful. The gravimetric method consists of weighing surgical linen and consumables before and after the operation. The colorimetric method based on dissolution of haemoglobin from used dressing materials in liquid medium with subsequent colorimetry of aqueous media from the wound should be considered the most accurate. The computational method is the most commonly used and consists of the use of specially developed formulas that include the estimation of haemoglobin and haematocrit before and after surgery [23, 29]. As the results, including our comparative studies, show, the use of several calculation methods is often accompanied by rather contradictory results [2, 3].

The goal of tangential necrectomy is to maximally selective excision of devitalised tissues with minimal possible blood loss. To reduce the volume of exfusion, a complex of measures is traditionally used, which can be divided into the correct choice of timing, depth and method of excision, features of intraoperative haemostasis, the use of tumescent technique and hemostatic tourniquets, as well as systemic haemostatic therapy.

The terms of burn scab excision. According to the team of authors led by M. Desai (1990), who performed 594 tangential necrectomies, it is advisable to perform this operation in victims with extensive burns in the first three days after the injury, as intervention in later periods is accompanied by significant blood loss. If it was not possible

to perform necrectomy in the early period, the author recommends excision of the scab not earlier than the second week after the injury. This position is quite logical, as by this time demarcation of the necrotic scab is formed. At excision of the scab in the burned person on the area of 30 % of the body surface the blood loss was 0.4 ± 0.06 ml/cm^2 at the operation in the first day and 0.49 ± 0.049 ml/cm^2 — after 16 days. Blood loss was 0.75 ± 0.02 ml/cm^2 when surgery was performed between 2 and 16 days [9].

The depth of excision. The choice of the depth of burn scab excision remains a controversial issue. According to some authors, the results of histological studies show that the average thickness of the dissected burn scab at tangential necrectomy was 1.7 ± 1.1 mm. The layer of viable tissue in this area occupied 41.2 % of the total thickness of the dissected tissue. In more than 25 % of cases excision did not reach viable tissue. Only in 10 % of cases the excised layer contained only dead tissue, without areas of removed viable tissue. Based on the data obtained, the authors concluded that the thickness of one tangentially excised layer of the scab is not much greater than the actual thickness of the entire skin and often contains viable tissue [22].

Some authors recommend a more radical technique of tangential necrectomy. The tactics of its performance in burns of more than 70 % of the body surface consisted in layer-by-layer excision of tissues up to viable subcutaneous fatty tissue. Surgical intervention was performed in the scope of tangential necrectomy with one-stage closure of wound defects with autografts no later than 7 days from the moment of injury, which was accompanied by good treatment results [27].

The method of excision. According to the author's data, mortality from burns has significantly decreased over the last few decades [13]. Its decrease is associated with a number of factors, including the improvement of surgical technique of tangential excision of necrotic tissues. Since its advent, this procedure has been under constant scrutiny to determine its proper scope and efficacy. To be successful, tangential excision must be performed with special attention to blood loss, patient temperature and tissue viability. The immediate results of its performance are quite different in different parts of the body, as confirmed by our own studies. According to a number of authors, the best cosmetic results of tangential excision are found in facial burns. The same point of view is held by S.L. Jeffery (2007), who showed the best cosmetic results of tangential excision in burns allows preserving intact tissues in order to achieve the maximum cosmetic effect and restore their functions in the distant period [15].

An interesting report was presented by authors from a Chinese burn centre [21]. They studied the efficacy of tangential necrectomy in the treatment of deep burn wounds of the trunk and extremities in children in the early postburn period. In the first comparison group, a roller knife was used for tangential excision. Visual absence of necrotic tissue at the wound bed was considered the proper depth of excision. Split skin grafts were used when adipose tissue was exposed after tangential excision. Patients in the second group underwent tangential excision early after the burn using an electric dermatome. The thickness was set at 0.1 mm, which allowed excision of the scab surface before the appearance of initial dot haemorrhages on the wound surface, which did not cause significant blood loss. At the same time, the aim of the operation was not the radical removal of the dead layer at the wound bed. After tangential excision, cell-free porcine dermal matrix was applied to the wounds in both groups. The first dressing change was performed 1 week after surgery. To close the wounds at later dates, skin grafting with a split skin graft was performed. The excised scab and the tissues of the wound bed of the patients were subjected to morphological examination. The thickness of the dissected scab in the patients in the second group was about 150 μm. The scab consisted of epidermis and the upper layer of dermis. Necrotic tissues remained on the wound bed. The duration of wound healing in patients of the second group who underwent minimally invasive tangential necrectomy was 24.8 ± 2.5 days, and the duration of antibiotic administration was 4.4 ± 0.7 days, while in the first group the wounds healed in 33.3 ± 2.5 days, and antibiotic administration lasted 7.0 ± 0.7 days. The authors concluded that treatment of deep and borderline burn wounds of the trunk and extremities by minimally invasive tangential excision with the use of electrodermatome in the early postburn period allows to reduce intraoperative blood loss, accelerate wound healing, and reduce the time of antibiotics administration.

Despite the significant number of devices developed for tangential necrectomy, including knives, the problem of accuracy and precision remains. Tangential necrectomy with a dermatome may result in less tissue loss but is accompanied by blood loss. The Versajet hydrosurgical system (Smith & Nephew, Hull, UK) is more favoured in some observations and provides more precise removal of dead tissue. The authors believe that the more precisely the scab is excised, the better surface can be prepared for future autodermotransplantation [24].

The intraoperative haemostasis. An important component of performing tangential necrectomy is the use of wound hemostasis techniques, as the most common cause of autodermotransplant rejection is haematoma. It is often impossible to stop bleeding from the wound surface without electrocoagulation, but this, in turn, prevents the split skin

graft from engrafting [6, 14]. In addition to gauze napkins with haemostatic solutions, special dressings with blood-saving effect are being developed. For example, NuStat®, the use of which at tangential necrectomy, according to the authors' data, is economically favourable in terms of costs for blood transfusion and other procedures to stop bleeding [6].

The tumescent technique. The main way to reduce blood loss during tangential necrectomy in most clinics is subcutaneous injection of adrenaline-saline solution under burn wounds and skin graft sites. In order to evaluate its effectiveness, the authors compared two groups: in the observation group subcutaneous injection of adrenaline solution into the donor sites and under the burn scab to be excised in combination with pneumatic tourniquets on the limbs and bandages soaked in physiological solution with adrenaline was carried out. In the comparison group, gauze compresses soaked in adrenaline-thrombin solution (1 ml of adrenaline 1:1000, thrombin 10 000 U, 1 l of physiological solution) were used for the purpose of hemostasis. Application of the above surgical tactics significantly reduced the average amount of transfused blood during surgery [20].

Other authors also recommend a number of measures to reduce intraoperative blood loss, including adrenaline infiltration of the donor site and burn wound, local injection of adrenaline into the donor site and excised wound, and tourniquets on the extremities. The estimated blood loss decreased from 211 ± 166 ml to 123 ± 106 ml per percentage of body surface area, including scab excision and autodermotransplantation. The use of a combination of measures during burn excision and transplantation resulted in a significant reduction in blood loss and the need for haemotransfusion [25].

The use of hemostatic tourniquets. The use of a tourniquet to reduce blood loss during radical excision of the dead tissue layer remains a controversial issue. In particular, the authors evaluated the results of the operation with and without the use of a tourniquet. The total blood loss appeared to be less with the tourniquet operation and was 0.19–0.58 ml/cm^2. At the same time the graft engraftment rate was the same in both observation groups and made 98.2 % [17]. According to other authors, the effectiveness of tourniquet application during tangential limb excision in burn patients to reduce surgical blood loss is undoubted, with a decrease in the amount of haemotransfusion and reduction of the operation time [7, 32].

In another study, the authors studied the clinical efficacy of early tangential excision of deep burn wounds without tourniquet application. Surgeons studied the experience of layer-by-layer and step-by-step tangential excision during the first day in 32 patients after stabilisation of hemodynamic parameters against the background of burn shock therapy. The operations were performed without a tourniquet. The depth of tangential excision was determined by the fact of development of uniform point bleeding of the bottom of the burn wounds. Wound haemostasis was carried out with adrenaline solution 1:1000 followed by application of cell-free xenogenic matrix on its surface. The volumes of intraoperative blood loss, duration of the operation, pre- and postoperative temperature, duration and quality of wound healing were recorded. The volume of intraoperative blood loss from a 1% body surface area wound was 8.8 ± 0.9 ml, the duration of surgery was 0.52 ± 0.06 minutes, and the duration of wound healing was 25.2 ± 2.2 days. The authors concluded that layer-by-layer tangential excision of the burn wound early without tourniquet application has the advantages of less intraoperative blood loss, shorter operation duration and simplified manipulations. The depth of tangential excision was also easier to control [16, 33]. Some authors report that there was no statistically significant difference in intraoperative blood loss from 1% of body surface area with and without tourniquet use [27, 28].

The system therapy. One of the approaches to reduce intraoperative blood loss is the systemic administration of drugs influencing the haemostasis system. Traditionally, their list includes temporary reduction (or cancellation) of anticoagulants in the preoperative period, administration of fresh frozen plasma and fibrinolysis inhibitors [4, 27].

CONCLUSION

Based on the data of literature sources, we can conclude that during tangential necrectomy the main adverse consequences are massive blood loss that develops due to excessive tissue removal and haematoma formation, and partial or complete loss of skin grafts caused by non-radical excision. Proceeding from this, a number of authors recommend detailed and clear formulation of the main indications and terms for performing these surgical interventions [19, 31].

The main methods of reducing surgical blood loss should be recognised as a personalised approach to the choice of timing, methods and depth of layer-by-layer excision of dead tissues, a differentiated approach to the use of hemostatic tourniquets and tumescent solution, combined systemic haemostatic therapy [12]. The volume of blood loss in burned patients can vary significantly, so to ensure safe surgery, it is necessary to take into account the individual clinical situation [10], which can be significantly affected by coagulopathy and thrombocytopenia characteristic of burn patients [8]. Despite the development of surgical technologies, the problem of blood loss during tangential necrectomy has not been completely solved. The results of using biological glue or hydrosurgical units need to be studied in more detail.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisi-tion, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

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Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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